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(19)

(54) IMPROVEMENTS IN OR RELATING TO THE CONTINUOUS MANUFACTURE OF BEER WORT

(71) We, FORSCHUNGSINSTITUT FUR DIE GARUNSINDUSTRIE, ENZYMOLOGIE UND TECHNISCHE MIKROBIOLOGIE, an East German Body Corporate, of 1017 Berlin, Alt-Stralau 62, East Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the continuous manufacture of beer wort.

Our co-pending Application No. 58008/68 (Serial No. 1,247,531) discloses a method for continuously manufacturing beer wort comprising the steps of continuously crushing malt grist, continuously mashing the crushed grist by a process in which the processing conditions are automatically controlled, filtering the mash on a continuously moving filter belt under vacuum to separate the first wort, sparging the grains remaining on said filter belt by means of water spray jets and withdrawing the spargings under vacuum and uniting at least a part of them with the first wort to form the required beer wort, removing the sparged grains from said filter belt at the end thereof and feeding the grains to a continuous conveyor therefor, washing residual material from the filter belt by water jets during its return travel, and feeding the removed residual material and the washing water to said continuous conveyor for the sparged grains.

The beer wort so produced may be boiled in a further stage or stages.

These said methods constitute a considerable advance as compared with the batch operation conventionally employed in brewing. So far as the system's cycle time, the efficiency of use of the raw materials and the space occupied by the plant, are concerned, these continuous methods offer substantial advantages.

The optimum use of the raw materials with a short mashing time requires the finest possible crushing and intensive processing of the mash. So far as the methods of our co-pending Application are concerned, the sparging of the mash, which is made up of fine-ground malt barley, is uneconomical because the layers of spent mash on the sparging belt are only very thin and it is also necessary to provide auxiliary filtering means. Moreover, in the known processes, the use of manual sparging imposes an upper limit on the fineness of the malt barley so that the extent to which the mashing time can be shortened, is limited. The processing of material in which there is a large proportion (greater than 40%) of raw grain in the total amount of material presents problems because of the complexity of the processing apparatus required. The method of boiling the wort described in our co-pending Application, while presenting the advantage of a substantial saving in time over batch boiling, nevertheless still requires too long a boiling time to be wholly compatible with a continuous process. Moreover, with indirect heating of the wort, there is the risk of increased precipitation on the heating surfaces; this can lead to fouling of the latter and impair the heat transfer as well as the flavour of the wort. The use of inert gases to gasify the boiled wort makes the overall process more expensive.

It is an object of the present invention to provide a method of continuous wort production which is an improvement over that disclosed in our co-pending Application No. 58008/68 (Serial No. 1,247,531), in particular in relation to the processing of raw grain, the sparging operation and the boiling of the wort.

According to the invention, there is provided a method of continuously manufacturing beer wort using, in addition to malt grain, a large amount of raw grain, including the steps of continuously crushing and mashing raw grain, mixing the mash

thus formed with malt mash separately produced, continuously effecting maltose formation and final saccharification of the mixed mash in the presence of enzymes, continuously separating the wort by centrifugal sparging, continuously boiling the separated wort under pressure by the direct injection of steam, expanding and cooling the boiled wort, hop extract being added to the wort before or during boiling, or at a later stage in the production of beer.

In a preferred embodiment of the invention, the raw grain is finely crushed, and hot-mashed at between 70 and 90°C whilst adding enzymes which decompose carbohydrates, partial preliminary liquefaction thus being achieved before processing. By the direct injection of steam, the raw grain mash is raised to a temperature of between 140 and 165°C and processed under pressure at this temperature. The pressure of this process stage is conveniently produced by a pump. After the requisite dwell time of about 50 to 300 seconds, the processed raw grain mash is cooled and mixed with the malt mash which has been produced by mashing finely crushed malt with water. This combined mash, in accordance with the proportion of raw grain, is mixed with an amylase-glucanase enzyme preparation in a manner known *per se* in order to compensate for the missing malt enzymes, this being effected after a reaction temperature of about 50°C has been produced. The mash, in order to undergo the mashing reactions, is subjected after the halt at 50°C., to the reaction stages of maltose formation and final saccharification, the temperature rise required in each case being produced by intermediate heat exchanges. Separation of the mash in order to carry out special processing of the thickened mash as described in our co-pending application referred to above, is unnecessary since, because of the high proportion of raw grain used, the major part of the starch-bearing constituents in the mash have already been boiled.

A horizontally disposed cylindrical reactor may be used, provided internally with shaft-mounted stirrer and screw-feed elements in order to maintain the aforementioned pauses together with an optimum dwell time of about 10 to 30 minutes; such a reactor may have a minimum length/diameter ratio of 3. In order to maintain the temperature constant, the reactors can be insulated; jacket heating is not absolutely essential.

Sparging is then effected at above 78°C by centrifugal techniques, using a combination of centrifuges and mixer vessels in order to rinse the spent grains. For optimum extract production, the excess extract-containing final run of the wort may be used in the mashing of the crushed raw grain and possibly also of the crushed malt.

Boiling of the wort then takes place under pressure at a temperature of between 160 and 120°C for a time of between 0.5 and 10 minutes, in a reaction tube system which can be either vertically or horizontally installed. The heating of the hot wort coming from the sparging phase is carried out by the direct injection of steam into the wort at the requisite temperature, because of the risk of increased precipitation and consequent fouling of the heating surfaces. The steam fraction which does not condense in the wort removes from the latter any volatile impurities during the boiling phase. The necessary precise observance of the dwell time in order to achieve adequate precipitation and to optimally dissolve the bitter principles which accompany the hop extract, in the case when hop extract is included at this stage, in addition to the other well-known objectives of boiling the wort (in dependence upon the quality and solubility of the hop extract), is achieved by the precise determination of the length of the reaction tube as a function of the wort flow rate. The flow rate of the wort-steam mixture through the reaction tube should be not less than 0.2 metres/second and should produce a turbulent flow condition, so that the precipitate has approximately the same dwell time in the tube as does the wort. Depending upon the method of preparation of the hop extract and its concentration, it may be introduced into the process either prior to heating or into the heated wort in the reaction tube or (if a hop extract is available which can be cold-processed) into the cold wort following filtration, or again, into the beer during a subsequent stage of production prior to filtration.

The wort, after boiling, leaves the reaction tube system and is expanded through a throttle valve to the pressure prevailing in a subsequent expansion vessel, this pressure being lower than the boiling pressure at a wort boiling temperature of between 120 and 160°C in the reaction tube system. Through the reduction in pressure to this level, brought about by the throttle valve, spontaneous steam bubble formation takes place in the wort which is superheated after throttling, such bubble formation leading to cooling of the wort.

It has been found that these steam bubbles which bubble extremely vigorously through the wort and set it in motion, flush out the volatile, unwanted flavouring substances and aromatics, such as for example hydrogen sulphide, which, in batch processes, are removed during the boiling of the wort, this action being due to the high affinity of the steam. The steam which does not condense in the wort during heating,

removes volatile substances from it directly during the boiling phase. The resultant vapour is drawn off and can be used, for example, for hot water production.

In order to prevent condensation of the vapour formed in the expansion vessel and cooling of the wort by dissipation of heat, the vessel can be externally insulated. The expansion vessel is provided with a wort inlet which distributes the mixture of wort and steam over the cross-sectional area of the vessel and allows the steam bubbles to bubble relatively uniformly through the hot wort at a minimum scrubbing level of 0.2 metres; a vapour outlet; and a wort discharge at the lowest point of the conical base of the vessel, this being designed to prevent deposits of precipitate.

The boiled hot wort at about 100°C is then fed to cooling and clarifying phases using a pump.

The method and apparatus described, make it possible to shorten the cycle time involved in mashing, sparging and, in particular, boiling, and thus to reduce the investment costs. In particular, a substantial reduction in the boiling time is attainable even indeed with batch operation, if appropriate preceding and succeeding vessels are used. By processing crushed malt which ranges from the fine to the very fine, maximum exploitation of the raw materials with the shortest possible mashing time is ensured, so that the operating costs can be reduced. By reducing the size of the apparatus and changing process stages, the installed volume of the apparatus is reduced. The apparatus for processing large proportions of raw grain (in excess of 40%) is simplified and the boiling of the wort is made cheaper because gasification with inert gases is unnecessary.

The invention will now be further explained with reference to the accompanying drawing which is a flowsheet of the boiling stage in a method according to the invention.

Raw grain is finely crushed in a crushing mill, enzymes which decompose carbohydrates being added, and hot mashing is then carried out using water at 70°C. A pump operating at a pressure of around 7.0 kg/cm² feeds the mash through a heater where the crude product mash is raised to a processing temperature of about 155°C by direct injection of steam, and through a processing vessel where it is processed for 120 seconds. After processing, indirect cooling in a heat-exchanger is effected and the mash is then combined with malt mash which has been produced by mixing finely crushed malt with water. The combined mash constituted by the raw grain and malt mashes then has an enzyme complex added to it. The mash successively passes through reactors responsible for a pause at 50°C, for maltose formation, and for final saccharification. Each reactor is followed by a heat-exchanger, these heating the mash respectively to the maltose formation, final saccharification and mash discharge temperatures. On reaching the mash discharge temperature of 70°C., centrifugal sparging is carried out. The excess, extract-containing last run of the wort is recycled to the mashing step, in particular, to the crude product mash. The wort obtained from the sparging operation enters a preliminary vessel 1 and by means of a pump 2 is fed through a reaction tube system 4 under a pressure of about 5.5 kg/cm². Before reaching the reaction tube system 4, the wort is heated to a boiling temperature of about 140°C in a steam-wort mixer 3 by direct injection of steam, and hop extract is also injected through a line 10*a* or a line 10*b* by a dosing pump 9. The pressure in the boiled wort, after the transit time of 4 minutes through the reaction tube system 4, is reduced by passage through a throttle valve 5 to the pressure of approximately 1.0 kg/cm² prevailing in an expansion vessel 6. The wort, superheated by the throttling operation, enters the expansion vessel 6 and is relatively uniformly distributed over the cross-sectional area thereof, and scrubs the 0.75 metre deep wort already contained in the expansion vessel, by means of the steam bubbles formed. Steam charged with volatile impurities is discharged at the head 7 of the expansion vessel. The scrubbed wort at about 95°C., is fed by a pump 8 to the hot precipitate extraction stage and then passes on to be cooled.

The dosing of the hop extract can, if the extract is suitably pretreated, be effected through a line 10*c* in the form of a cold hop product which is injected into a stage following fermentation and maturation of the wort.

WHAT WE CLAIM IS:—

1. A method of continuously manufacturing beer wort using, in addition to malt grain, a large amount of raw grain, including the steps of continuously crushing and mashing raw grain, mixing the mash thus formed with malt mash separately produced, continuously effecting maltose formation and final saccharification of the mixed mash in the presence of enzymes, continuously separating the wort by centrifugal sparging, continuously boiling the separated wort under pressure by the direct injection of steam, expanding and cooling the boiled wort, hop extract being added to the wort before or during boiling, or at a later stage in the production of beer.

2. A method of continuously manufacturing beer wort using, in addition to malt

grain, a large quantity of raw grain, comprising the steps of:—

(a) finely crushing the raw grain;

(b) hot-mashing the crushed raw grain at 70° to 90°C with the addition of one or more liquefying enzymes;

(c) processing the mashed raw grain at 140° to 165°C under pressure by the direct injection of steam;

(d) cooling the mash so produced and combining it with malt mash which has been produced by mixing finely crushed malt with water;

(e) adding to the combined mash so produced at a temperature of about 50°C., an amylase-glucanase enzyme preparation;

(f) subjecting the combined mash in continuous flow to the process stages of maltose formation and final saccharification, the requisite temperature increases being produced by intervening heat exchanges;

(g) separating the wort from the spent grain by centrifugal sparging;

(h) boiling the wort under pressure at a temperature of 160° to 120°C for a time of 0.5 to 10 minutes by the direct injection of steam into the wort, hop extract being added to the wort prior to the heating thereof or to the heated wort, or, using an appropriately prepared extract, to the cold wort at a later stage of the beer production, the uncondensed fraction of the steam introduced serving to remove volatile impurities from the boiling wort:

(i) expanding the boiled wort into an expansion vessel, whereby spontaneous steam bubble formation takes place; and

(j) cooling the expanded wort.

3. A method as claimed in Claim 2, wherein the extract-containing last run of the wort obtained in step (g) is recycled to step (b).

4. A method as claimed in Claim 2 or Claim 3 wherein step (h) is carried out in a reaction tube system such that the wort has a dwell time therein of 0.5 to 10 minutes at a flow rate rate of not less than 0.02 m/sec.

5. A method as claimed in any one of Claims 2 to 4, wherein in step (i), the steam bubbles formed bubble through the hot wort at a minimum scrubbing level of 0.2 metres.

6. A method as claimed in any one of claims 2 to 5 wherein step (b) is carried out in a horizontally disposed cylindrical reactor provided with stirring and screw-feed elements arranged on an internal shaft and an unheated insulating jacket and having a length/diameter ratio of at least 3.

7. A method of continuously manufacturing beer wort substantially as hereinbefore described with reference to the accompanying drawing.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*